Ontario Geological Survey

Aggregate Resources Inventory Paper 5

AGGREGATE RESOURCES INVENTORY OF MULMUR TOWNSHIP DUFFERIN COUNTY SOUTHERN ONTARIO

by

Staff of the Engineering and Terrain Geology Section

Ontario Geological Survey

1980

Ontario

Ministry of Natural Resources

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and price list
are obtainable through the
Ontario Ministry of Natural Resources, Map Unit, Public Service Centre,
Queen's Park, Toronto, Ontario
and
The Ontario Government Bookstore
880 Bay Street, Toronto, Ontario.

Orders for publications should be accompanied by cheque
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ISSN 0708-2061
ISBN 0-7743-4445-8

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Parts of this publication may be quoted if credit is given to the Ontario Ministry of Natural Resources, Ontario Geological Survey. It is recommended that reference to this report be made in the following form:

Ontario Geological Survey
1980: Aggregate Resources Inventory of Mulmur Township, Dufferin County, Southern Ontario; Ontario Geological Survey, Aggregate Resources Inventory Paper 5, 33p., 6 tables, 3 maps, scale: 1:50 000.

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ABSTRACT

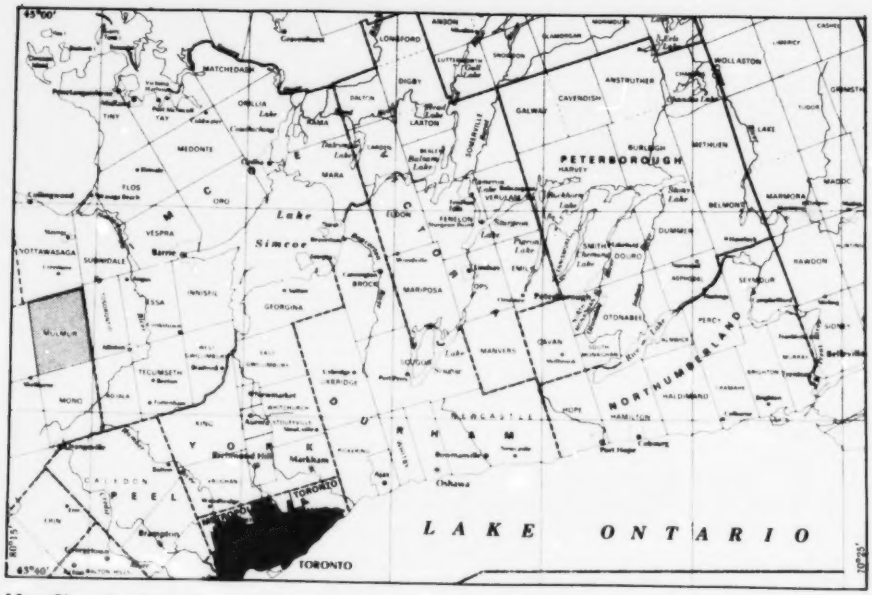


Figure 1. Key Map Showing Location of Mulmur Township. Scale 1:1 800 000.

An inventory and evaluation of aggregate resources, which includes crushed stone derived from bedrock as well as natural sand and gravel, was completed for Mulmur Township in 1979. This is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971. The aggregate resources in the township have been assessed according to standards developed for the Program.

In Mulmur Township, four areas containing significant amounts of sand and gravel have been selected for possible resource protection. Selected Sand and Gravel Resource Areas compose 2700 acres (1090 ha), exclusive of licenced areas. An estimated 2290 acres (930 ha) are currently available for extraction, containing possible resources of approximately 120 million tons (109 million tonnes). The available parts of the Selected Areas represent 5 percent of the total area occupied by sand and gravel deposits in the township and 4 percent of the total resource tonnage.

Selected Sand and Gravel Resource Area 1, an outwash deposit near the southern boundary of the township, constitutes the most important natural aggregate deposit in Mulmur Township. The deposit contains an estimated 26 million tons (24 million tonnes) of sand and crushable gravel suitable for a variety of road-building and construction uses.

Sand and Gravel Resource Areas 2, 3, and 4, all of which are composed of outwash sand and gravel, have also been selected for possible resource protection. Resource Areas 2 and 3 are located in the central portion of the township, near Black Bank and Terra Nova; Resource Area 4 is located along the western boundary to the west of Kilgorie. Areas 2,3 and 4 contain an estimated 94 million tons (85 million tonnes) of sand with minor crushable gravel suitable for a variety of road-building and construction uses.

Mulmur Township has sand and gravel resources which should be sufficient for local use for a considerable period of time. Care should be taken to ensure the continuing availability of these resources.

Possible aggregate resources derived from bedrock in Mulmur Township are from the Amabel and Queenston Formations. The Amabel Formation is a source for many crushed stone products suitable for use in road and building construction. Four areas have been selected for resource protection, containing an estimated resource of 575 million tons (522 million tonnes).

Stone from the Queenston Formation is suitable for brick and tile manufacture, and is a regionally important resource. Two areas have been selected for possible resource protection, containing an estimated 130 million tons (118 million tonnes).

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF MULMUR TOWNSHIP

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1976, the total tonnage of mineral aggregates extracted was greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1977).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Wherever possible, field examination of potential resource areas was also undertaken to confirm interpretations made in the office. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-size fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Air photos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

In the office, the pit data were supplemented by information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot thick layer of sand and gravel, one acre in extent, assuming an average density of 110 pounds per cubic foot.

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2).

Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favourrable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot thick section of dolostone, one acre in extent, assuming a bulk density of 165 pounds per cubic foot).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot or approximately 3200 tons per acre. Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975,p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

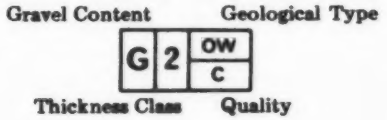
PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Map 1 is derived directly from the existing surficial geology maps of the area or from air photo interpretation where surficial mapping is incomplete. It shows the extent of sand and gravel deposits within the study area and serves as a base for the calculation of the total sand and gravel resources.

Map 1 presents a summary of all available information related to the quantity and quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbol which identifies each deposit. The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel. If no information is available, the letters are omitted.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit as discussed in the next section.

The other information presented on Map 1 is designed to give an indication of the present level of extractive activity in the study area. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits are also identified and numbered on Map 1 and described in Table 2.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary, and tertiary. These areas are identified on Map 2 by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a medium-grey tone on Map 2.

Selected Aggregate Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light grey tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no grey tone. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent crushable gravel are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" or high silt and clay content may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" particles (those greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building

aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O" or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data

or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical well data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the labelled bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three tones. The darkest tone indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance due to their easy access. The medium tone indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest tone indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Three factors support this approach. Quality and quantity variations are gradual. The areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material. Since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The wider range of possible resource areas allows greater flexibility in locating quarry operations away from areas of intensive land use competition. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN MULMUR TOWNSHIP

LOCATION AND POPULATION

Mulmur Township occupies an area of 71,296 acres (28 854 ha) on the Niagara Escarpment, in the northeast corner of Dufferin County. It is shown on portions of the Collingwood, Dundalk and Alliston map sheets of the National Topographic System, at a scale of 1:50 000.

There are no major population centres in the township. Local settlements include Honeywood, Mansfield and Violet Hill. The Town of Shelburne to the southwest, and the Town of Orangeville to the south, serve as regional trade and retail centres for the area. The population of the township consists mainly of rural-farm inhabitants with a small but growing number of rural-residential and seasonal, recreational residents. Total population has increased slightly over the past few years to its present level of 1804 (Ontario Ministry of Intergovernmental Affairs 1979; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974, 1977).

Road access in the area is provided by a rectangular grid of paved and gravel-surfaced county and township roads. The main paved road is King's Highway 89.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The Niagara Escarpment dominates the physiography of Mulmur Township. Local relief is nearly 800 feet (244 m) along Black Bank Hill in the north, where the Escarpment is a simple mantled scarp with a 50- to 75-foot (15 to 23 m) exposed face. Black Bank Hill is a separated part of the Escarpment, produced by headward erosion in two stream valleys which now form connecting re-entrants in the scarp. In the central and southwestern portion of the township, the Escarpment is marked by large re-entrant valleys now occupied by the Pine and Boyne Rivers, respectively. South of the Pine River valley, the Escarpment is stepped in two scarps. The upper scarp is a bare rock face consisting of Amabel limestone, just east of Whitfield. The lower scarp is partially mantled and composed of Queenston shales.

The Niagara Escarpment divides the township into two physiographic regions: a thin drift zone to the west and a plain of thick drift cover to the east. The form and distribution of unconsolidated sediments in both regions are the result of glacial and glaciofluvial activity during the Late Wisconsinan Stage of the Pleistocene Epoch, between 23,000 and 12,500 years ago.

Most of the Province was covered by a massive glacial advance approximately 18,000 years ago. The ice margins then retreated from the area, but the ice readvanced as two semi-independent lobes approximately 15,000 years ago. This advance of the ice deposited till which now forms a rolling, drumlinized till plain covering much of western Mulmur Township. The till is a gritty clayey silt till which forms the parent material for soils with good agricultural potential (Hoffman *et al.* 1964).

The ice margins then retreated from the area, but later the ice readvanced over the Niagara Escarpment. The ice halted and deposited vast amounts of sand, gravel and till in a large terminal moraine, known as the Orangeville Moraine, just at the brow of the Escarpment. The southeastward retreat of the ice margin from the Orangeville Moraine, down to the base of the Escarpment, led to the development of an extensive meltwater channel system carrying sediment southward between the Escarpment and the ice margin. Extensive outwash terrace gravels were deposited at this time, forming the Lavender-Violet Hill meltwater channel (Gwyn 1972, 1975). Two terraces are present at Violet Hill: one at 1425 feet (434 m) above sea level (a.s.l.) and a lower terrace at 1350 feet (412 m) a.s.l. The upper unit consists of 10 to 13 feet (3 to 4 m) of gravel underlain by pebbly, silty medium sand.

The ice margin retreated from the Escarpment, then readvanced briefly to the same location, depositing till in the eastern part of the township, and building the Singhampton-Gibraltar Moraine just east of the Lavender-Violet Hill meltwater channel (Gwyn 1975, p.56). This moraine trends north from Violet Hill to Kilgorie. Local relief is 50 to 150 feet (15 to 46 m) and topography is irregular and hummocky. The poorly sorted fine sand and gravel of the moraine form the parent material for good crop soils except in hilly areas where they are droughty and easily eroded (Hoffman *et al.*

1964).

The last glacial readvance in the area came again from the northeast but did not reach the Escarpment. Vast amounts of fine-grained sediments were carried west from the ice margin and deposited in an extensive outwash plain between the ice margin and the Escarpment in the east-central portion of the township. These deposits consist of a surface unit of silty medium sand 6 to 30 feet (2 to 9 m) thick which overlies great thicknesses of interbedded sand, gravel, till and silt.

After the final melting of glacial ice in the area, the Pine and Boyne Rivers and their tributaries began incising deep channels into the outwash plain. Three terrace levels were produced: at approximately 1075 feet (328 m) a.s.l., at 975 feet (297 m) a.s.l. and at 925 feet (282 m) a.s.l. The terrace sediments were derived from the outwash plain and closely reflect its composition. Texturally, the terrace aggregate is coarser and better sorted than the surrounding outwash material (Gwyn 1975, p.57).

EXTRACTIVE ACTIVITY

Numerous pits have been opened in Mulmur Township. Many have become inactive since designation of the township under The Pits and Quarries Control Act, 1971. At the time of writing, only three sources were licenced for extraction. Two of these sources are located on the Lavender-Violet Hill meltwater channel, at the southern boundary of the township. The third is located in Black Bank Hill. It is estimated that available resources on presently licenced properties are approximately 2.0 million tons (2.0 million tonnes).

Average annual production for Mulmur Township, including production from licenced sources as well as from wayside pits for which permits are required, has been estimated at 0.1 million tons (0.1 million tonnes).

SELECTED SAND AND GRAVEL RESOURCES

Sand and gravel in Mulmur Township covers a total area of approximately 45,200 acres (18 300 ha) or 63 percent of total area of the township. Much of the material included in this estimate has low potential for use. Deposits containing 35 percent gravel or more are termed "crushable" and have been assigned a primary significance. These deposits cover an area of 2700 acres (1090 ha) (exclusive of licenced areas) and occupy only 4 percent of the township's area.

Four deposits have been selected as Resource Areas. The Selected Sand and Gravel Resource Areas in this study correspond generally to areas discussed by Gwyn (1976) in an earlier study of the aggregate resources of Mulmur Township.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1, located along the southern border of the township, is the upper terrace of the Lavender-Violet Hill meltwater channel (the southern extension of this area in Mono Township has also been selected as a Resource Area).

Two pits in the area are presently licenced. A 30-foot (9 m) face at Pit No. 1 exposes uniform outwash gravel with sandier material at the bottom of the face. The amount of crushable gravel ranges from 30 to 40 percent. The quality of the aggregate is limited by several factors. Extensive selection and sand control are required to produce crushed products; significant amounts of siltstone and shale prohibit use of the aggregate for concrete or for most hot-laid asphaltic mixes; finally, the fine aggregate is often too dirty to produce asphaltic mixes (Deike 1977).

Resource Area 1 has an area of 450 acres (182 ha), exclusive of licenced areas. The land surface of the deposit is smooth and fairly level except for small scale erosion at the terrace scarps. Most of the land is cleared and under cultivation. Allowing for cultural setbacks, the area currently available for extraction is estimated to be 410 acres (166 ha). Assuming an average deposit thickness of 25 feet (8 m), possible resources in Area 1 are calculated to be approximately 26 million tons (24 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 is located in a deltaic complex built by southward-flowing meltwater during an early phase in the development of the Lavender-Violet Hill meltwater channel. The delta forms a lobate-shaped

plain on the edge of the Escarpment at an altitude of 1425 feet (434 m).

The sediments in this Area consist of an upper unit of gravel overlying interbedded gravel and medium to coarse sand. The deposit may be more than 40 feet (12 m) thick (Gwyn 1975, p. 102). Gravel content ranges from 40 to 60 percent. Several pits have been opened in the deposit, one of which (Pit No. 3) is presently licenced.

Selected Resource Area 2 has an area of 820 acres (330 ha), exlusive of licenced areas. Allowing for cultural setbacks, the area currently available for extraction is calculated to be 760 acres (308 ha). Assuming an average deposit thickness of 25 feet (8 m), estimated possible resources are 48 million tons (44 million tonnes).

The deposit surface is generally smooth and level, but has been deeply dissected by tributaries of the Pine River. The steep, wooded slopes along the stream valleys may be inaccessible for extractive development. The deposit lies entirely within the Niagara Escarpment Planning Area and Telford and Narain (1976) have identified it as a high priority resource area for extractive development.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3 consists of two outwash terraces produced by the down-cutting action of the Pine River. The upper terrace, located in the vicinity of Terra Nova, is approximately 975 feet (297 m) a.s.l., although both terraces grade downwards to the east and distinctions are not easily made. No pits have been opened in the area, but water well information indicates that 18 to 50 feet (6 to 15 m) of gravelly sand may be available for extraction.

Selected Resource Area 3 covers 1240 acres (500 ha). No licences have been issued in the area. A considerable area is unavailable, especially in the western half of the deposit, west of Terra Nova, due to cultural setback allowances. Less than 50 percent of the land is cleared for agriculture, the rest being left in bush and woodlots. Thus, the area currently available for extraction is calculated to be 940 acres (380 ha). Assuming a minimum deposit thickness of 16 feet (5 m), estimated resources total 38 million tons (34 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Sand and Gravel Resource Area 4 is the eastern tip of a large, outwash deltaic complex near Horning's Mill in adjoining Melancthon Township. A pit in that township exposes 20 to 30 feet (6 to 9 m) of sandy gravel (20 percent gravel, 80 percent sand). The deposit has 180 acres (73 ha) currently available for extraction in Mulmur Township, containing an estimated 8 million tons (7 million tonnes) of sand and gravel.

SAND AND GRAVEL RESOURCES OF SECONDARY SIGNIFICANCE

An outwash sand deposit in the vicinity of Mansfield has been selected as a Sand and Gravel Resource Area of Secondary Significance. Gwyn (1975, p.102) describes three small pits opened in this area. Faces in the pits expose interbedded medium sand, pebbly sand, and sandy gravel ranging in thickness from 6 to 60 feet (2 to 18 m). Water well data indicate thicknesses of sandy material from 3 to 20 feet (1 to 6 m). Much of the material in this area may be usable for sand cushion and other low specification road-building products.

The lower terrace of the meltwater channel in the vicinity of Selected Sand and Gravel Resource Area 1 has also been identified as a Resource Area of Secondary Significance. This deposit consists of silty medium sand, pebbly sand, and minor gravel. Moderate amounts of aggregate suitable for fill and sand cushion may be available.

BEDROCK GEOLOGY

Mulmur Township is underlain by a succession of Ordovician and Silurian sedimentary rock units. These units are exposed in sequence from the oldest in the northeast corner of the township, to the youngest in the west. The units trend roughly southeast-northwest and have a gentle regional dip to the southwest. The names and stratigraphic relationships of the units are summarized on the legend accompanying Map 3 (after Bond and Telford 1976; Liberty *et al.* 1976 a, b).

Shale of the Whitby Formation occurs in the extreme northeast corner of the township. There are no surface exposures. Drift cover is

generally greater than 100 feet (30 m), therefore precluding economic quarrying (Gwyn and Fraser 1975 a, b).

The Georgian Bay Formation overlies the Whitby Formation and occurs throughout central and northeastern Mulmur Township, and in the valley of the Pine River as far west as Kilgorie. Although extensively drift-covered, the Georgian Bay Formation is exposed in several places along the sides of the Pine River valley, as well as in several smaller tributary valleys. The Georgian Bay Formation has been quarried near Toronto for brick manufacture and recent testing has indicated that the rock is suitable for heat-expanded, lightweight aggregates. Because of the present limited demand for this product and the presence of better exposures elsewhere, the Georgian Bay Formation is not likely to be quarried in Mulmur Township.

The Georgian Bay Formation is overlain by red shale of the Queenston Formation, which forms the base of the Niagara Escarpment. Exposures are common in stream valleys throughout the area, and along small scarps, especially east of Whitfield. The Queenston shale is well suited for brick and tile manufacture, and has been quarried near Toronto. In several areas in Mulmur Township, drift cover is thin enough to permit economic quarrying of the shale.

The formations of the Clinton and Cataract Groups underlie the lower mantled portion of the main Escarpment face. Some of the formations have been quarried elsewhere in the past for building stone and road aggregate (Hewitt 1972, p.9). The Manitoulin Formation is at the surface in the northern part of Black Bank Hill and could possibly be worked economically in that area.

Massive, fine-crystalline dolostone of the Amabel Formation forms the exposed face and brow of the Escarpment, and underlies the entire western portion of Mulmur Township. The Amabel is an important provincial source of good-quality crushed stone. It is characterized by soundness, resistance to abrasion and resistance to weathering processes. The crushed stone is suitable for use as road-building and construction aggregate. Several areas west of the scarp face are favourable for extractive development.

The Guelph Formation overlies the Amabel Formation and occurs under relatively thick drift in the extreme southwest. A quarry was operated in the Guelph Formation a few miles to the southwest, in Amaranth Township. This quarry has long since been abandoned. Stone was extracted there to produce lime for cement manufacture.

Although quarries had been opened in all of the above mentioned units at various localities throughout the Province, no quarries have been established within Mulmur Township.

SELECTED BEDROCK RESOURCES

AMABEL FORMATION

The dolostone of the Amabel Formation constitutes an aggregate resource of Province-wide significance. The Formation is overlain by thin drift in several areas in western Mulmur Township. Four areas have been selected for resource protection.

SELECTED BEDROCK RESOURCE AREA 1

Selected Bedrock Resource Area 1 consists of 1680 acres (680 ha) surrounding Honeywood in the western portion of the township. Allowing for cultural setbacks, the area currently available for extraction is 1500 acres (610 ha). The estimated workable thickness is 50 feet (15 m). Therefore, available resources are calculated to be approximately 270 million tons (245 million tonnes). No licences are presently held in the area.

Drift thickness in the area generally ranges from 15 to 25 feet (5 to 8 m) and consists of two till units. The surface unit is a sandy silt till which poses relatively few extraction problems. It is underlain by a dense, compact pebbly silt till that is difficult to excavate and may render stripping costs prohibitive.

Road access to the area is good. Area 1 lies entirely within the Niagara Escarpment Planning Area, and was identified by the Ontario Ministry of Natural Resources in its assessment of industrial mineral resources in the Niagara Escarpment Planning Area (Telford and Narain 1976). It was given a high priority rating as a regionally important resource area.

SELECTED BEDROCK RESOURCE AREAS 2 AND 3

Selected Bedrock Resource Area 2, along the northern boundary of the township, is much the same as Area 1 with respect to quality of the material, and thickness and characteristics of the overburden. Area 2 has an available acreage of 660 acres (267 ha) and resources are estimated to be 119 million tons (108 million tonnes).

Selected Bedrock Resource Area 3, is the remainder of the Amabel caprock, overlying the Manitoulin Formation on top of the separated Black Bank Hill of the Escarpment. The available portion of Area 3 is 870 acres (350 ha) with a resource tonnage estimated to be 157 million tons (142 million tonnes). Drift cover is less than 25 feet (8 m) throughout the area and surface exposures are common.

Soils in Resource Area 3 are considered to be essentially nonagricultural (Hoffman *et al.* 1964). The landscape in the vicinity is distinctive for its aesthetic and recreational value. This may impose serious constraints on extractive developments. In addition, road access to the area is poor because of the hilly topography. Area 3 lies entirely within the Niagara Escarpment Planning Area and was also identified by Telford and Narain (1976) as a high priority resource area.

SELECTED BEDROCK RESOURCE AREA 4

Selected Bedrock Resource Area 4 consists of two small areas in the extreme southwest corner of the township, near Primrose. The overburden is largely clayey silt till. Areas of minimal drift thickness occur along the west boundary of the township and along the brow of the south side of the Boyne River valley. Assuming an estimated quarriable depth of 50 feet (15 m), available resources are 30 million tons (27 million tonnes).

Soils in Area 4 are poorly drained. Muck and organic material have accumulated in several depressions (Hoffman *et al.* 1964).

QUEENSTON FORMATION

The Queenston Formation consists of soft, friable red and green shales. The formation is an important provincial resource, serving as the raw material for much of the brick manufactured for residential construction in Ontario. It is also used for ceramic products such as drainage tile.

SELECTED BEDROCK RESOURCE AREA 5

The Queenston shales and the underlying Georgian Bay Formation are extensively exposed or are thinly drift covered throughout Selected Bedrock Resource Area 5, north of Perm and Mansfield. The two formations form a low, east-facing scarp a few miles east of the Niagara Escarpment.

The total potential resource area of this portion of the Queenston Formation, including areas exposed at the surface and areas underlain by less than 25 feet (8 m) of overburden, is estimated to be 480 acres (190 ha). Assuming a maximum quarriable depth of 60 feet (18 m), resources are estimated to be 93 million tons (84 million tonnes).

The overburden consists of a veneer of till on the brow of the scarp and fine outwash sand mantling the lower scarp face. The Area has recreational value as shown by the ski run located in the northern section.

SELECTED BEDROCK RESOURCE AREA 6

Selected Bedrock Resource Area 6 is the northern extension of an area selected for possible resource protection in Mono Township. Area 6 lies in the extreme southeast corner of Mulmur Township. Drift cover is generally less than 25 feet (8 m). The Area has an available acreage of 190 acres (77 ha), and assuming a maximum quarriable depth of 60 feet (18 m), has an estimated resource of 37 million tons (34 million tonnes).

SUMMARY

Selected Sand and Gravel Resource Areas in Mulmur Township have an available acreage of 2290 acres (930 ha) and contain approximately 120 million tons (109 million tonnes) of aggregate material. These Areas contain most of the available crushable gravel in the township. Resource Areas of Secondary Significance contain large quantities of sand. Part of the Selected Sand and Gravel Resource Areas have previously been identified as high priority areas (Gwyn 1976; Telford and Narain 1976).

Mulmur Township has large possible resources of bedrock-derived crushed stone suitable for most uses. Dolostone of the Amabel Formation is the major resource. The total available extent of Selected Resource Areas in this formation is 3200 acres (1300 ha) and the total estimated resource tonnage is 575 million tons (522 million tonnes). The Resource Areas are relatively thinly drift covered, but stripping may be a problem in some areas. Possible resources of bedrock suitable for brick, tile and other clay products are also large.

Enquiries regarding the Aggregate Resources Inventory of Mulmur Township should be directed to the Ontario Ministry of Natural Resources either at the Huronia District Office, Midhurst, Ontario, LOL 1X0 (tel. (705) 729-2900) or at the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (tel. (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MULMUR TOWNSHIP

1 CLASS NO.	2 DEPOSIT TYPE (See Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-OW	1500 (610)	94 (85)
	S-OW	24,300 (9800)	1820 (1651)
	S-IC	11,300 (4600)	760 (690)
2	G-OW	1300 (530)	46 (42)
	S-OW	1280 (520)	42 (38)
	G-IC	1300 (530)	49 (44)
	S-IC	3900 (1580)	135 (122)
3	S-IC	290 (117)	4 (4)
4	S-IC	30 (12)	< 1 (< 1)
		45,200 (18 300)	2950 (2676)

N.B. Minor variations in above table are due to rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, MULMUR TOWNSHIP

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1	D4-19	Chalmers Flear	Pt.W½ 1	2EHS	28.0 (11.3)	20 (6)	55-70
2	D4-20	Albion Sand & Gravel	SE¼ 1	2EHS	40.0 (16.2)	15 (5)	20
3	D4-123	Peace Valley Ranch	Pt.22	1E&W	27.0 (11.0)	25 (8)	
					95.0 (38.4)		
UNLICENCED PITS							
4	D4-10	McCutcheon	23	1WHS		30 (9)	18
5	D4-112	H. Gilles Pie	25	5			
6	D4-52	Sherman	11	2EHS		13 (4)	
7	D4-126	Clark	E½ 10	1WHS			
8	D4-53	Mulmur Gallagher	5	3EHS		10-15 (3-5)	50
9	D4-45	White (D.H.O. P-1835)	1	3EHS&4		20 (6)	
10	D4-91	G. Parson	1	3EHS		20-30 (6-9)	30

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, MULMUR TOWNSHIP.

1	2	3	4	5	6	7
	UNLICENCED AREA	CULTURAL SETBACKS	EXTRACTED AREA	AVAILABLE AREA	ESTIMATED DEPOSIT THICKNESS	AVAILABLE AGGREGATE
Deposit No.	Acres (Hectares)	Acres (Hectares)	Acres (Hectares)	Acres (Hectares)	Feet (Metres)	Millions of Tons (Tonnes)
1	450 (182)	40 (16)	NIL	410 (166)	25 (8)	26 (24)
2	820 (330)	60 (24)	NIL	760 (308)	25 (8)	48 (44)
3	1240 (500)	300 (121)	NIL	940 (380)	16 (5)	38 (34)
4	190 (77)	10 (4)	NIL	180 (73)	18 (6)	8 (7)
	2700 (1090)	410 (166)	NIL	2290 (930)		120 (109)

N.B. Minor variations in above table are due to rounding of data.

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, MULMUR TOWNSHIP.

1	2	3	4	5
DRIFT THICKNESS Feet (Metres)	**FORMATION**	**WORKABLE THICKNESS** Feet (Metres)	**AREAL EXTENT** Acres (Hectares)	**ORIGINAL TONNAGE** Millions of Tons (Tonnes)
0-3	Amabel	50	30	5
(0-1)		(15)	(12)	(4)
3-25	Amabel	50	3670	660
(1-8)		(15)	(1480)	(599)
25-50	Amabel	50	5700	1030
(8-15)		(15)	(2310)	(934)
			9400	1695
			(3800)	(1538)
0-3	Georgian Bay	60	20	4
(0-1)		(18)	(8)	(4)
3-25	Georgian Bay	60	680	131
(1-8)		(18)	(275)	(119)
25-50	Georgian Bay	60	4050	780
(8-15)		(18)	(1640)	(708)
			4750	915
			(1920)	(830)
3-25	Manitoulin	25	1930	174
(1-8)		(8)	(780)	(158)
25-50	Manitoulin	25	1790	161
(8-15)		(8)	(720)	(146)
			3720	335
			(1510)	(304)
0-3	Queenston	60	25	5
(0-1)		(18)	(10)	(4)
3-25	Queenston	60	1800	350
(1-8)		(18)	(730)	(318)
25-50	Queenston	60	7000	1340
(8-15)		(18)	(2830)	(1216)
			8800	1695
			(3550)	(1538)
			26,700	4640
			(10 800)	(4209)

N.B. Minor variations in above table are due to rounding of data.

TABLE 5 | QUARRIES, MULMUR TOWNSHIP.

1	2	3	4	5	6	7
NO.	**MTC NO.**	**OWNER/OPERATOR**	**LOT**	**CON.**	**LICENCED AREA** Acres (Hectares)	**FACE HEIGHT** Feet (Metres)
			NONE			

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, MULMUR TOWNSHIP.

1	2	3	4	5	6	7	8
DEPOSIT NO.	DEPTH OF OVERBURDEN Feet (Metres)	UNLICENCED AREA Acres (Hectares)	CULTURAL SETBACKS Acres (Hectares)	EXTRACTED AREA Acres (Hectares)	AVAILABLE AREA Acres (Hectares)	ESTIMATED DEPOSIT THICKNESS Feet (Metres)	AVAILABLE AGGREGATE Millions of Tons (Tonnes)
		AMABEL FORMATION					
1	3-25 (1-8)	1680 (680)	180 (73)	NIL	1500 (610)	50 (15)	270 (245)
2	3-25 (1-8)	750 (304)	90 (36)	NIL	660 (267)	50 (15)	119 (108)
3	3-25 (1-8)	920 (372)	50 (20)	NIL	870 (350)	50 (15)	157 (142)
4	3-25 (1-8)	200 (81)	30 (12)	NIL	170 (69)	50 (15)	30 (27)
		3550 (1437)	350 (142)		3200 (1300)		575 (522)
		QUEENSTON FORMATION					
5	3-25 (1-8)	560 (230)	80 (32)	NIL	480 (190)	60 (18)	93 (84)
6	3-25 (1-8)	210 (85)	20 (8)	NIL	190 (77)	60 (18)	37 (34)
		770 (310)	100 (40)		670 (270)		130 (118)
		4320 (1750)	450 (182)		3870 (1570)		705 (640)

N.B. Minor variations in above table are due to rounding of data.

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APPENDIX B-GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

CAMBRIAN

The first Period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A Period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DIRT

See fines.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No.200 mesh screen (0.074 mm). Also described informally as "dirt", these particles are in the silt- and clay-size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder		>-256 mm
Gravel	cobble	64-256 mm
Gravel	pebble	4-64 mm
Gravel	granule	2-4 mm
Sand	coarse	.5-2 mm
	medium	.25-.5 mm
	fine	.074-.25 mm
Silt, clay		<.074 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

H.L. (HOT-LAID OR ASPHALTIC AGGREGATE)

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago. The Paleozoic Era (or Ancient Life Era) is subdivided into six geologic Periods, of which only four (Cambrian, Ordovician, Silurian, and Devonian) can be recognized in southern Ontario.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity.

POSSIBLE RESOURCE

Reserves estimates based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SILURAIN

An early Period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 85,000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C-GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 7000 to 85 000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley, The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain-size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt-and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. They vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain-size variability. They are given a qualitative

rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. They occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain-size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from,

and deposited on , pre-existing lacustrine sand plain deposits. Windblown sediments are almost invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D-GEOLOGY OF BEDROCK DEPOSITS

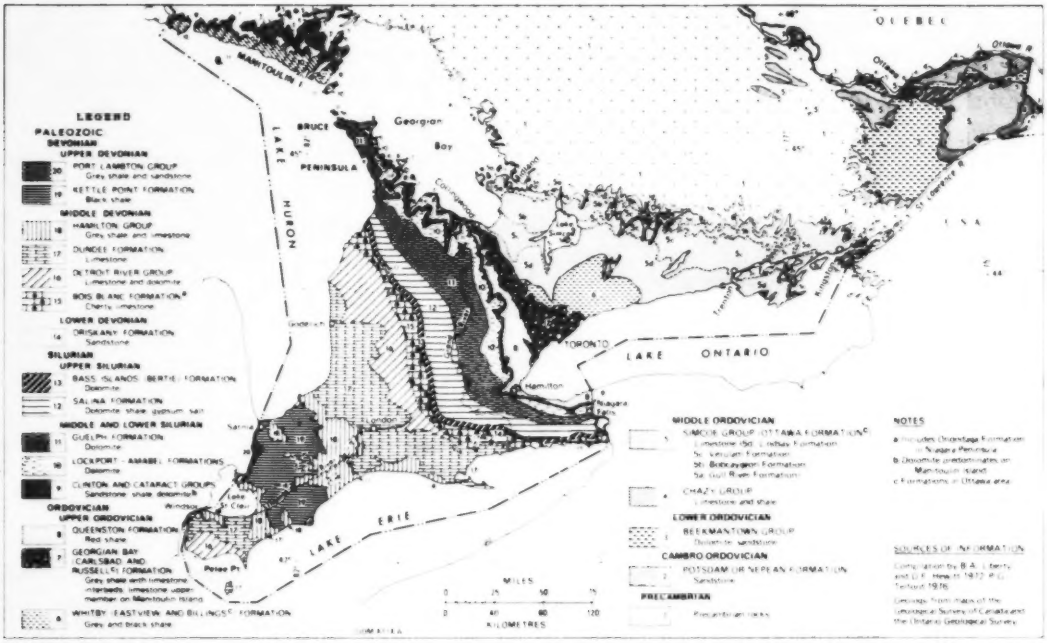


Figure 2 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11-18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion

Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin-to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Georgetown to the Bruce Peninsula): massive, fine crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Georgetown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, and building stone throughout their area of occurrence, and are a valuable aggregate resource. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliffe Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137-145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES.

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change). Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important

source of high purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic- to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. It is quarried at Glen Christie and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular, weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point, Colborne, and Bowmanville for lime. It is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200-300 feet (61-91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for lime. It is unsuitable for crushed stone due to clay impurities and many clayey interbeds, low abrasion resistance, high soundness losses and poor freeze-thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas). Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Five producers in Metro Toronto and Cooksville produce brick and structural tile (Guillet 1967). Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The Group has six formations. Only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are 12 large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa (Guillet 1967). All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

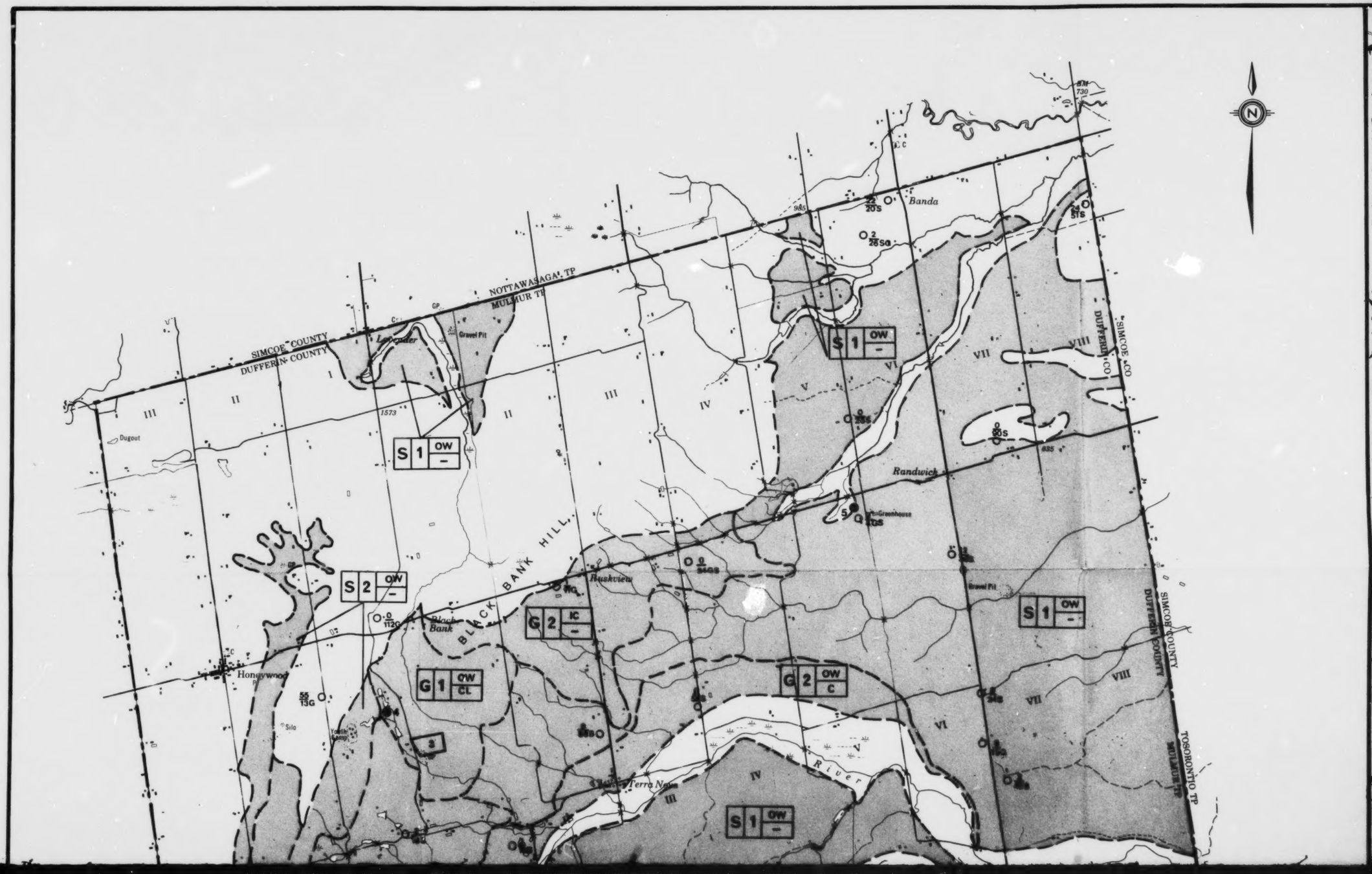
Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

SALINA FORMATION (UPPER SILURIAN)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amhertsburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto). Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggretage.


SIMCOE COUNTY
DUFFERIN COUNTY
NOTTAWASAGA TP
MULMUR TP
Landowner
Gravel Pit
Banda
Randwick
Greenhouse
Bushview
Black Bank
BLACK BANK HILL
Honeywood
Silo
Dugout
Terra Nova
River
TOSORONTIO TP
SIMCOE CO
DUFFERIN COUNTY
S 1 OW –
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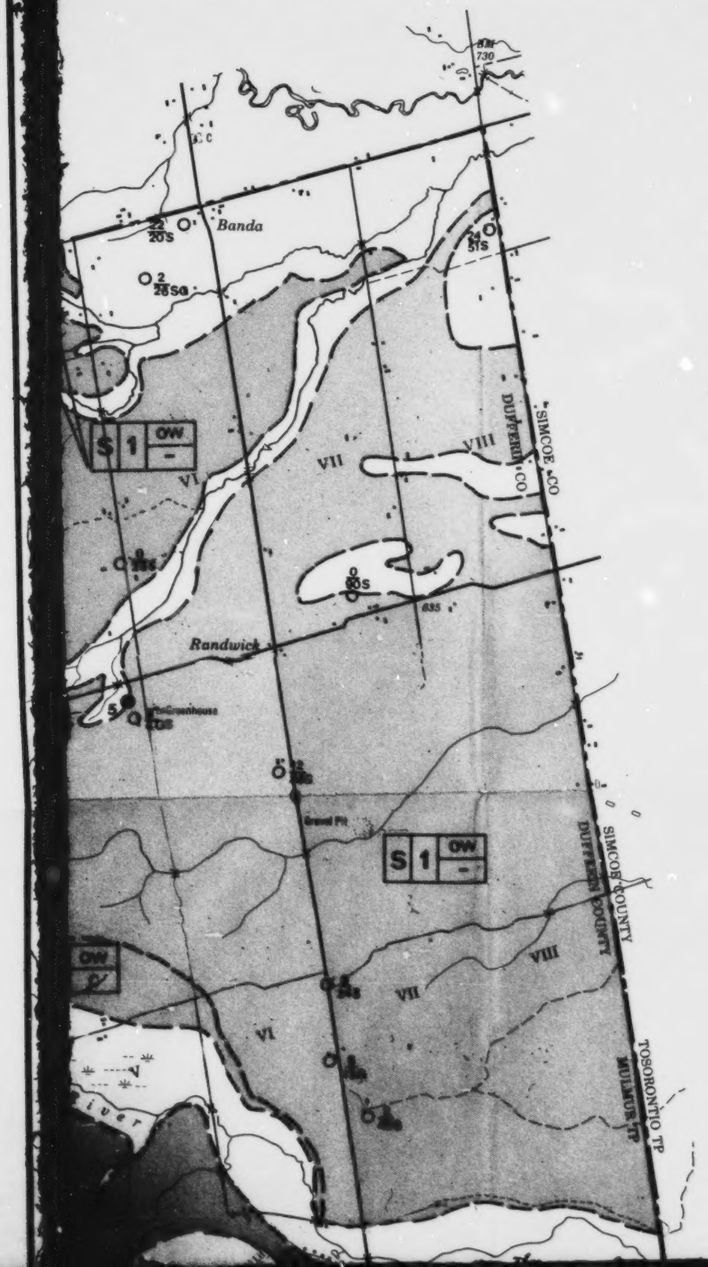

Ministry of Natural Resources

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

Ontario

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

MULMUR TOWNSHIP
DUFFERIN COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale: 1:50,000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference. **41 A/1, 41 A/8, 31 D/4W**

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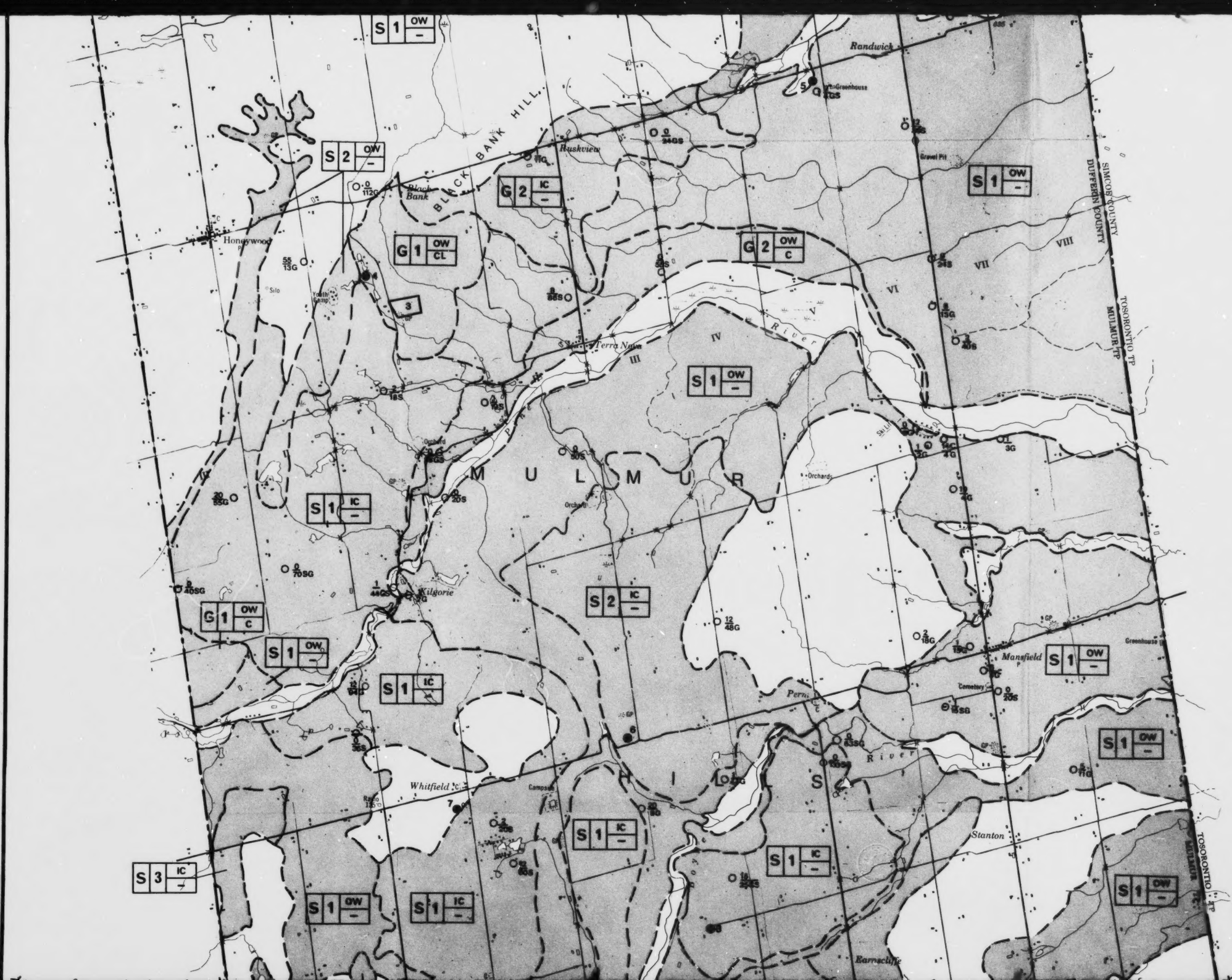
SYMBOLS

Geological and aggregate thickness boundary. Shading indicates deposit area.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)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S 2 OW –
G 2 IC –
G 1 OW CL
G 2 OW C
S 1 OW –
S 1 IC –
S 3 IC –
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S 2 IC –
S 1 OW –
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BLACK BANK HILL
Randwick
Ruskview
Black Bank
Honeywood
Silo
Youth Camp
Terra Nova
River
MULMUR
Orchard
Kilgorie
Whitfield
Campsite
Stanton
Earnscliffe
Mansfield
Cemetery
Greenhouse
Gravel Pit
SIMCOE COUNTY
DUFFERIN COUNTY
TOSORONTIO TP
MULMUR TP
I
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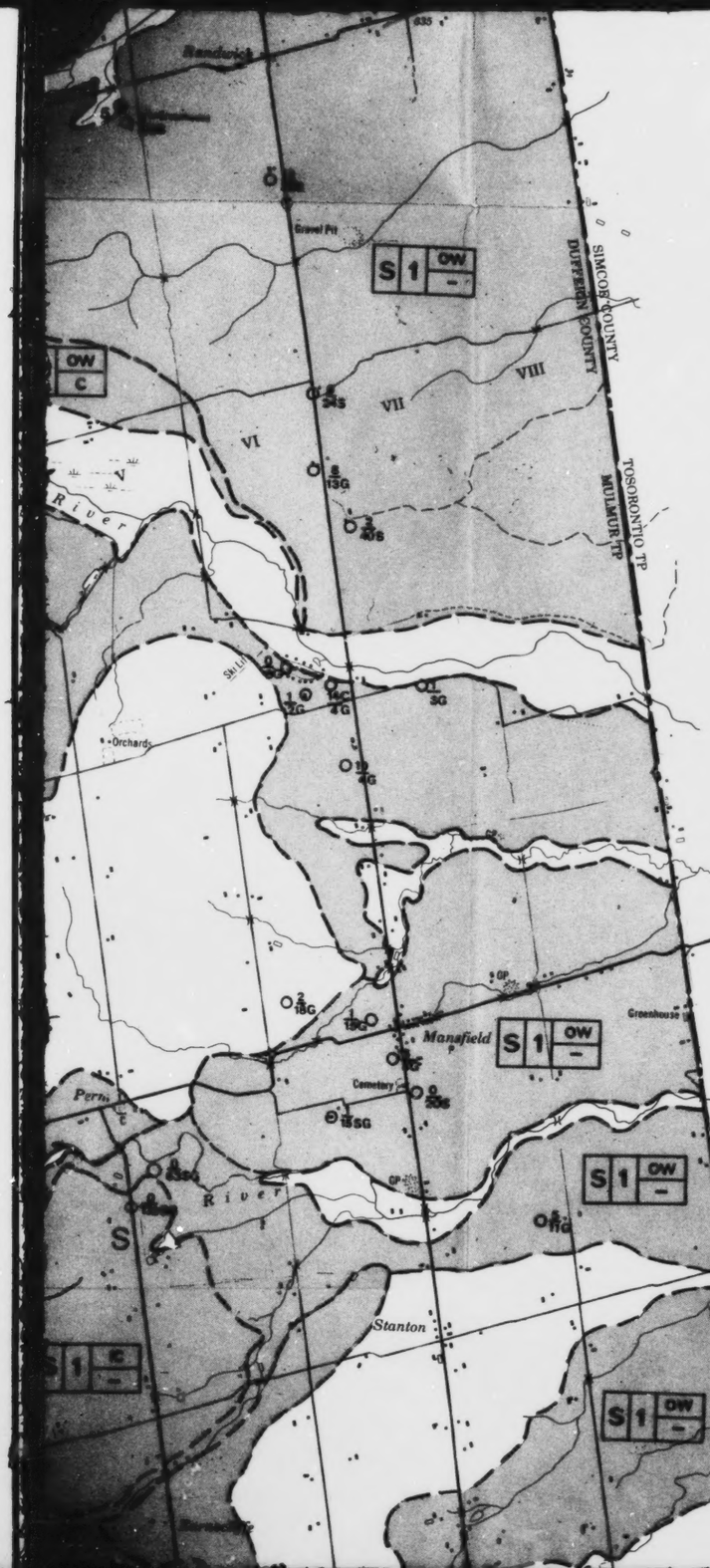
VII
VIII



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SYMBOLS

Geological and aggregate thickness boundary. Shading indicates deposit area.

S 1 IC CLO — Deposit symbol: see below.

3 — Licenced property boundary; Property number: see Table 2.

4 — Unlicenced sand or gravel pit; Property number: See Table 2.

6/23 — Selected drilling location indicating thickness of overburden overlying reported thickness of granular materials (in feet). (Note: S-sand, G-gravel, C-clay, T-till)

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, deposit type and quality indicators. Gravel content is expressed as percentage of crushable material. Classes are based on potential aggregate tonnage per acre and are designated numerically. Type refers to geologic origin. Quality modifiers indicate variations in grain size distribution and lithology.

Gravel Content	Thickness Class	Geological Type
		Quality Indicators

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.
?	Requires investigation

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 18 500)
2	10-20 (3-6)	25,000-50,000 (9 000-18 500)
3	5-10 (1.5-3)	12,500-25,000 (4 500-9 000)
4	less than 5 (< 1.5)	less than 12,500 (< 4 500)

Geological Type

IC	Undifferentiated Ice-Contact Stratified Drift	OW	Outwash
ICT	Ice-Contact Terrace	LB	Lacustrine Beach
K	Kame	LP	Lacustrine Plain
E	Esker	LD	Lacustrine Delta
EM	End Moraine	AL	Older Alluvium
		WD	Windblown Forms

(see Appendix C for descriptions of Geological Types.)

Quality Indicators

	If blank, no known limitations present
C	Clay and/or silt (fines) present in objectionable quantities
L	Deleterious lithologies present
O	Oversize particles or fragments present in objectionable quantities
	Requires investigation

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
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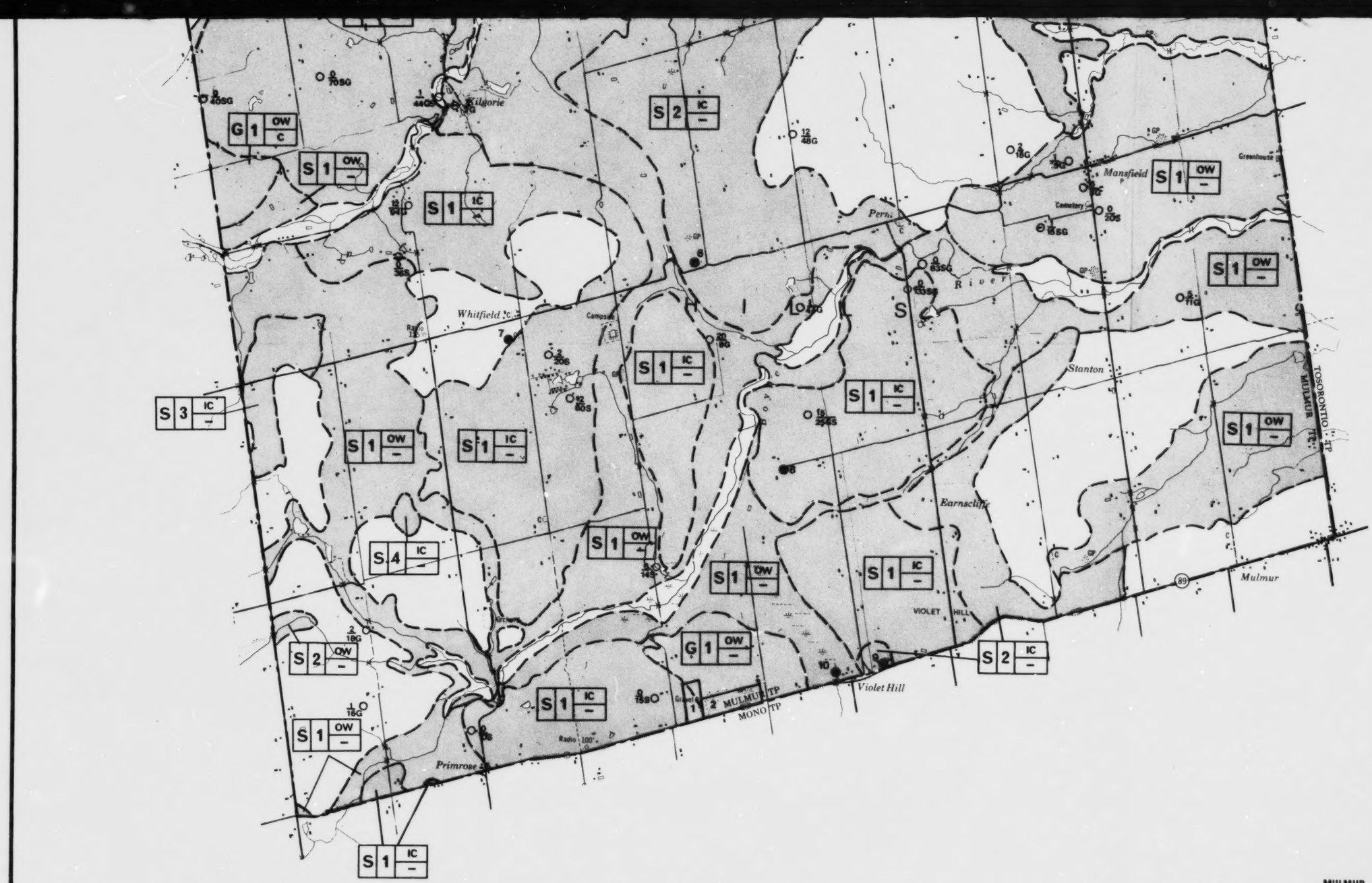
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural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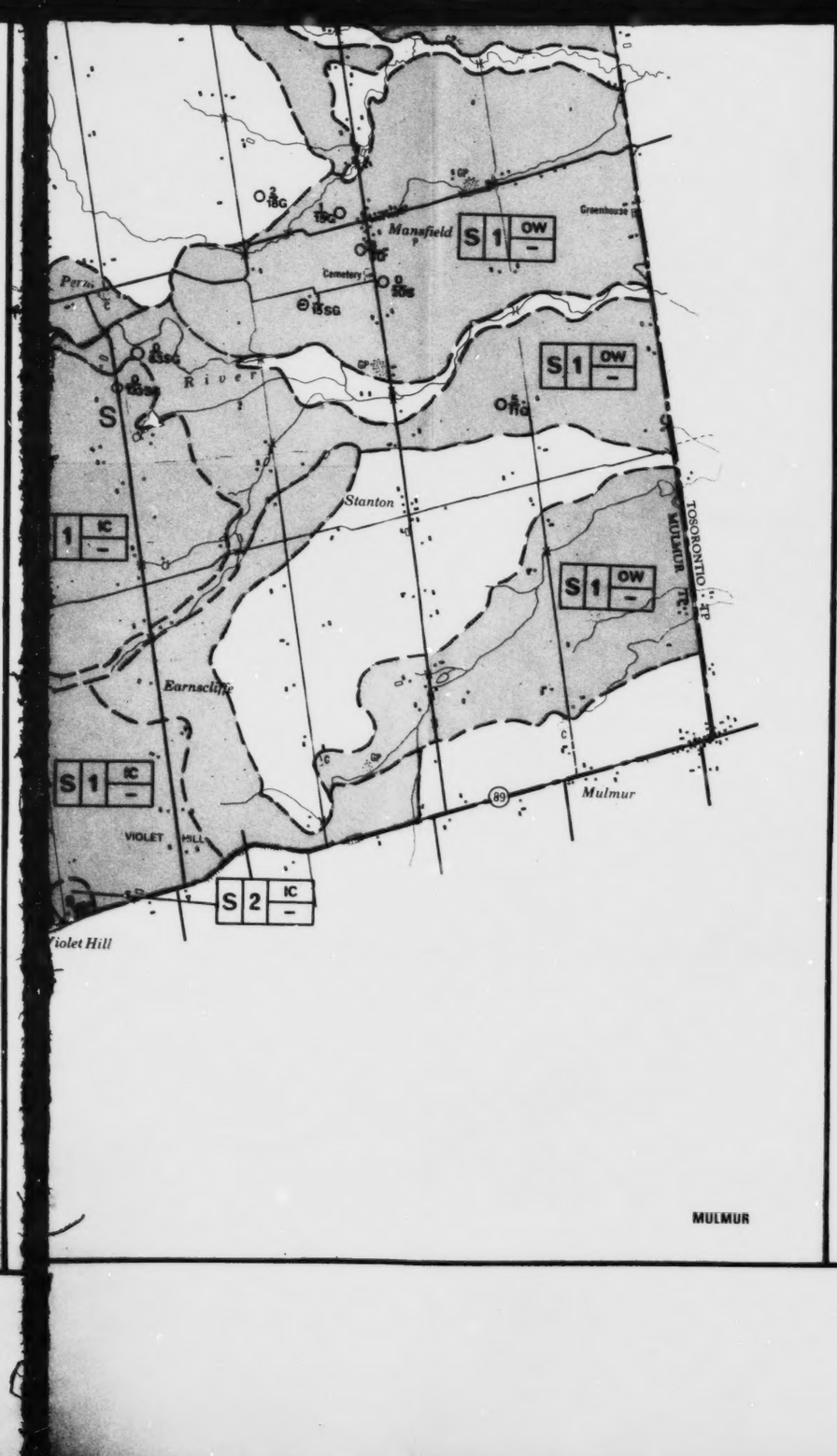
Primrose
Manafield
Stanton
Earnscliffe
Violet Hill
Mulmur
VIOLET HILL
MULMUR TP
MONO TP
TOSORONTIO
Radio 100
Greenhouse
Cemetery
Campsite
G 1 OW C
S 1 OW –
S 1 IC –
S 2 IC –
S 3 IC –
S 4 IC –
S 2 OW –
S 1 OW –
S 1 IC –
S 1 OW –
S 1 IC –
S 1 OW –
S 1 IC –
G 1 OW –
S 1 IC –
S 1 OW –
S 1 IC –
S 2 IC –
S 1 IC –
MULMUR



MULMUR

overlying reported thickness of granular materials (in feet). (Note: S-sand, G-gravel, C-clay, T-till)

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, deposit type and quality indicators. Gravel content is expressed as percentage of crushable material. Classes are based on potential aggregate tonnage per acre and are designated numerically. Type refers to geologic origin. Quality modifiers indicate variations in grain size distribution and lithology.

Gravel Content	Thickness Class	Geological Type
		Quality Indicators

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.
?	Requires investigation

	(1.5-3)	12,500-25,000 (4 500-9 000)
4	less than 5 (< 1.5)	less than 12,500 (< 4 500)

Geological Type

IC	Undifferentiated Ice-Contact Stratified Drift	OW	Outwash
		LB	Lacustrine Beach
ICT	Ice-Contact Terrace	LP	Lacustrine Plain
K	Kame	LD	Lacustrine Delta
E	Esker	AL	Older Alluvium
EM	End Moraine	WD	Windblown Forms

(see Appendix C for descriptions of Geological Types.)

Quality Indicators

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O.L. White, 1975

Compilation and drafting by C. M. Kwiatkowski

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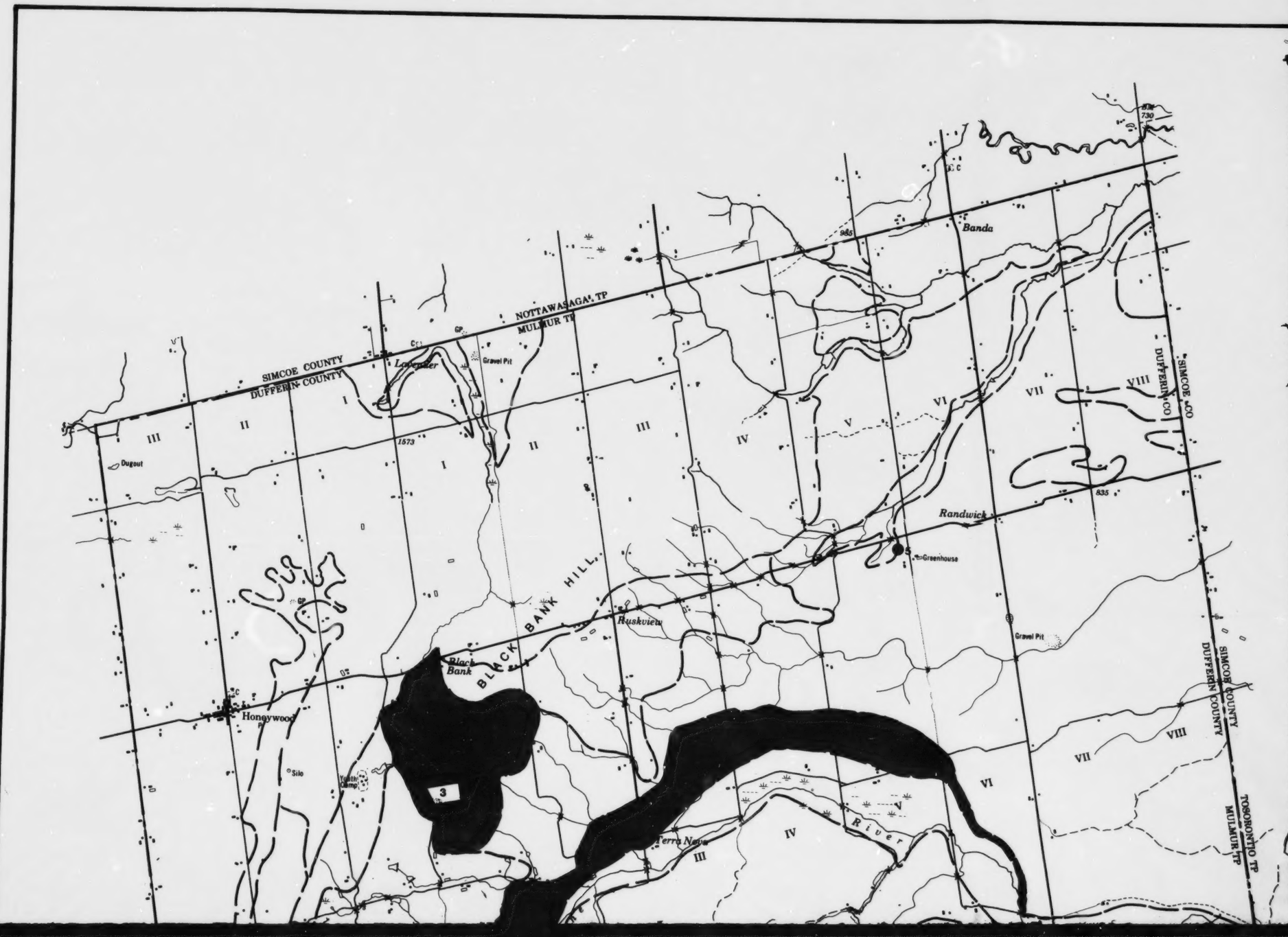
SIMCOE COUNTY
DUFFERIN COUNTY
NOTTAWASAGA TP
MULMUR TP
Lavender
Gravel Pit
Banda
985
730
1573
Dugout
Randwick
835
Greenhouse
BLACK BANK HILL
Ruskview
Black Bank
Honeywood
Silo
Terra Nova
River
Gravel Pit
SIMCOE COUNTY
DUFFERIN COUNTY
TOSORONTIO TP
MULMUR TP
I
II
III
IV
V
VI
VII
VIII
3

Ontario

Ministry of Natural Resources

Hon. James A.C. Auld
Minister

Dr. J.K. Reynolds
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

MULMUR TOWNSHIP

DUFFERIN COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: **41 A/1, 41 A/8, 31 D/4W**

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SYMBOLS
(Some symbols may not apply to this map)

Geological and aggregate thickness boundary.

Randwick
Greenhouse
Gravel Pit
Huskview
Black Bank
BLACK BANK HILL
Honeywood
Silo
Youth Camp
3
SIMCOE COUNTY
DUFFERIN COUNTY
TOSORONTIO TP
MULMUR TP
VIII
VII
VI
V
IV
III
Terra Nova
River
M U L M U R
Orchards
Kilgorie
Mansfield
Perm
6
River
H I L L S
Whitfield
Radio 1250
Stanton
8
Earnscliffe

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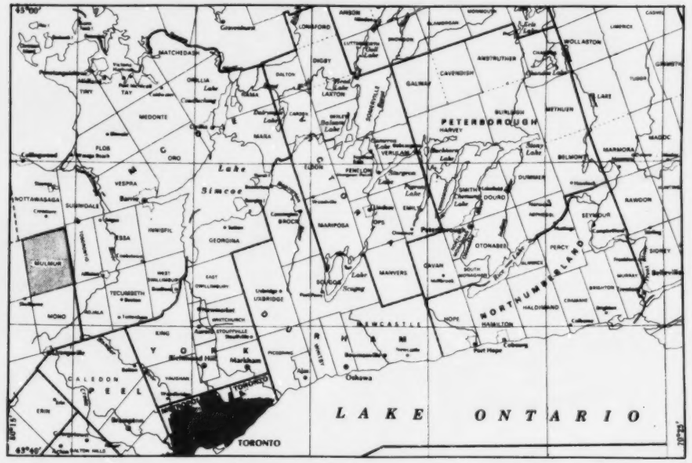

SYMBOLS
(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- 2 — Licenced property boundary; Property number: see Table 2.
- ●4 — Unlicenced sand or gravel pit; Property number: See Table 2.

SOURCES OF INFORMATION

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Kilgorie

Mansfield

Greenhouse

Cemetery

Perm

GP

6

River

H I L L S

Whitfield

Radio 125°

Campsite

7

Stanton

8

Earnscliffe

VIOLET HILL

Mulmur

10

9

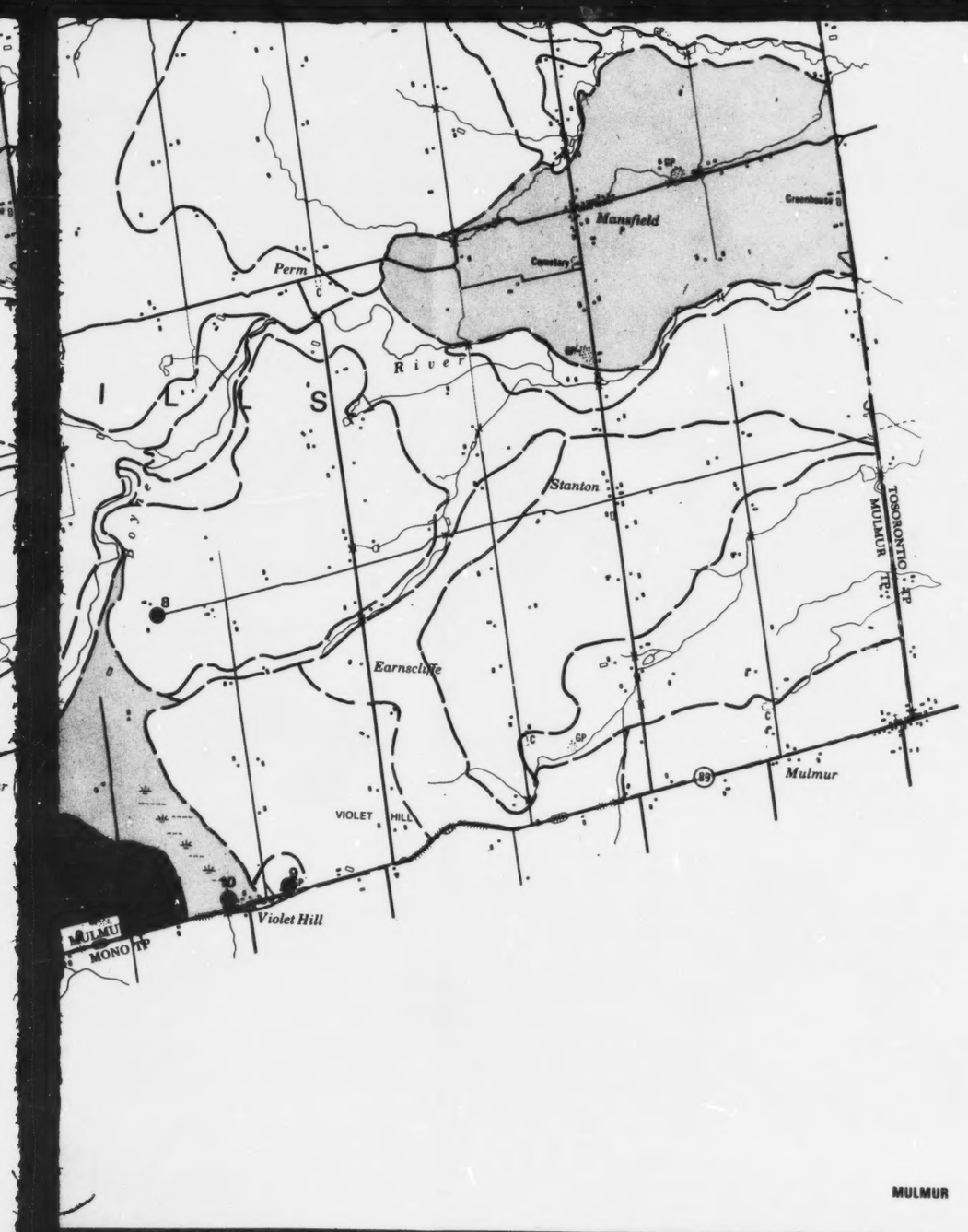
Violet Hill

Grawlyn 1

MULMUR MONO TP

Radio 100°

Primrose



● 4 Unlicenced sand or gravel pit; Property number: See Table 2.

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MULMUR
CLINTON AND
CATARACT GROUPS
NOTTAWASAGA TP
MANITOULIN
FORMATION
AMABEL FORMATION
QUEENSTON
FORMATION
GEORGIAN BAY FORMATION
WHITBY
FORMATION
Banda
Randwick
Greenhouse
Gravel Pit
Terra Nova
Black Bank
Lavender
SIMCOE COUNTY
DUFFERIN COUNTY
TOSORONTIO TP
MULMUR TP
River

Ontario

Ministry of Natural Resources

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Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

MULMUR TOWNSHIP

DUFFERIN COUNTY

MAP 3
BEDROCK RESOURCES

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: **41 A/1, 41 A/8, 31 D/4W**

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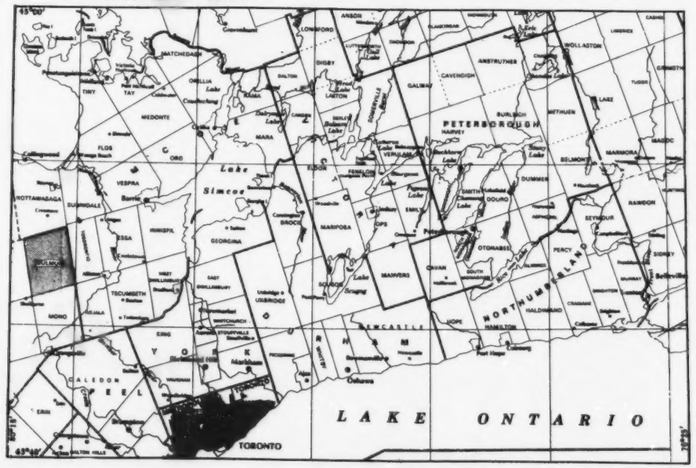


LEGEND

PALEOZOIC

SILURIAN

MIDDLE AND LOWER SILURIAN

GUELPH FORMATION
Dolostone

ORDOVICIAN

UPPER ORDOVICIAN

QUEENSTON FORMATION
Red shale

AMABEL FORMATION

QUEENSTON FORMATION

GEORGIAN BAY FORMATION

CLINTON AND CATARACT GROUPS
MANITOULIN FORMATION

AMABEL FORMATION

QUEENSTON FORMATION

CLINTON AND CATARACT GROUPS
MANITOULIN FORMATION

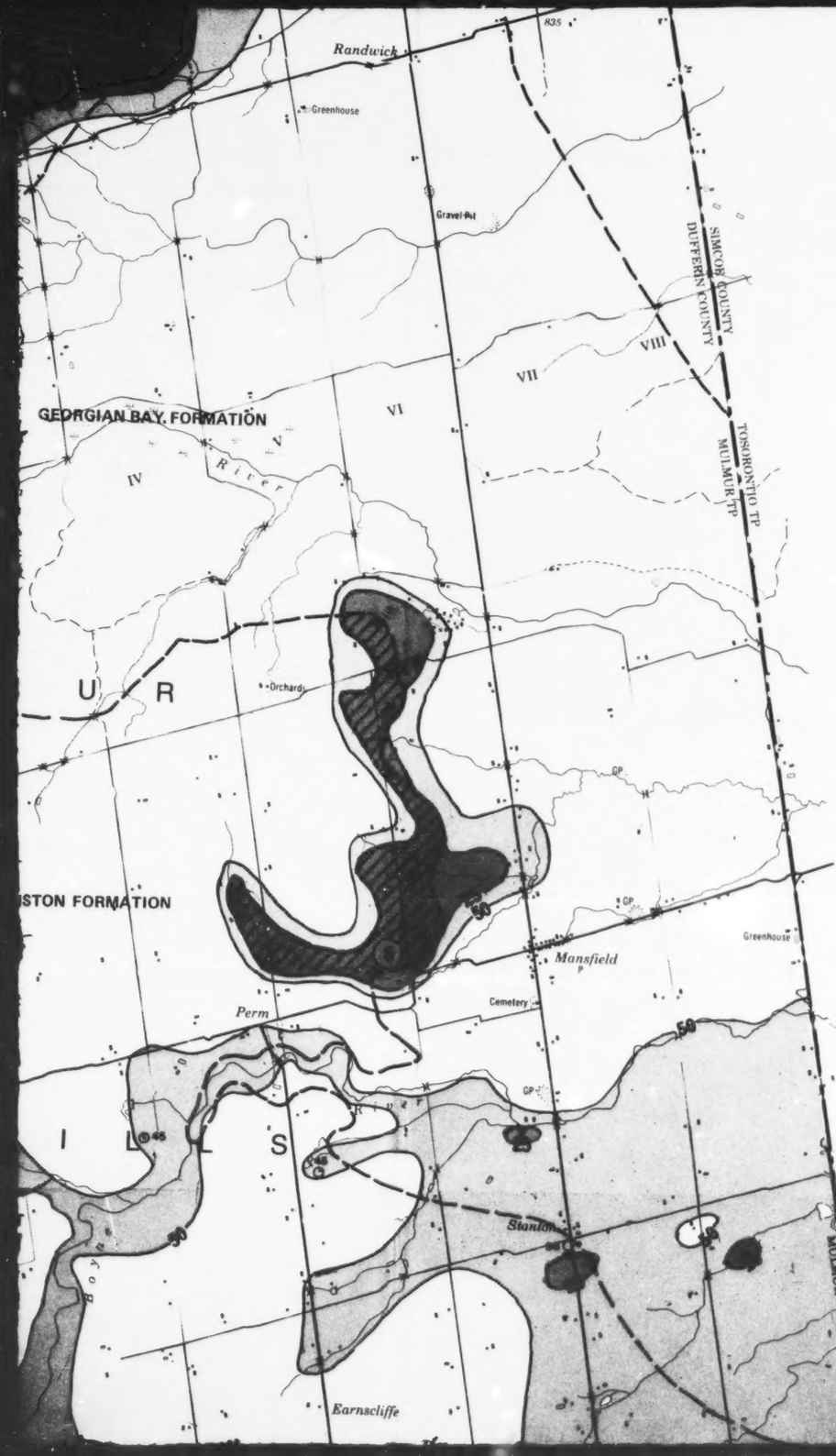
AMABEL FORMATION

M U L M U R

H I L L S

SIMCOE COUNTY
DUFFERIN COUNTY
TOSORONTIO TP
MULMUR TP

Randwick
Greenhouse
Gravel Pit
Black Bank
Sula
Terra Nova
Orchard
Kilgorie
Mansfield
Cemetery
Perm
Whitfield
Radio 1250
Stanton
Earnscliffe
Pine River
Boyne River



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LEGEND

PALEOZOIC

SILURIAN

MIDDLE AND LOWER SILURIAN

GUELPH FORMATION
Dolostone

AMABEL FORMATION
Dolostone

CLINTON AND CATARACT GROUPS
Sandstone, shale, dolostone

MANITOULIN FORMATION
Dolostone

ORDOVICIAN

UPPER ORDOVICIAN

QUEENSTON FORMATION
Red shale

GEORGIAN BAY FORMATION
Grey shale with limestone interbeds

WHITBY FORMATION
Grey and black shale.

SYMBOLS

(Some symbols may not apply to this map.)

- Geological boundary.
- 25 — Drift thickness contour line (25 foot (8 m) interval).
- x — Isolated bedrock outcrop.
- Bedrock within 3 feet (1 m) of surface: see Table 4.
- Bedrock covered by 3 to 25 feet (1 m to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 m to 15 m) of overburden: see Table 4.
- (1) — Selected bedrock resource area; Deposit number: see Table 6.
- 2 — Licenced quarry boundary; Property number: See Table 5.
- ●Q4 — Unlicenced quarry; Property number; See Table 5.
- ○27 — Selected drilling location indicating reported depth to bedrock (in feet).

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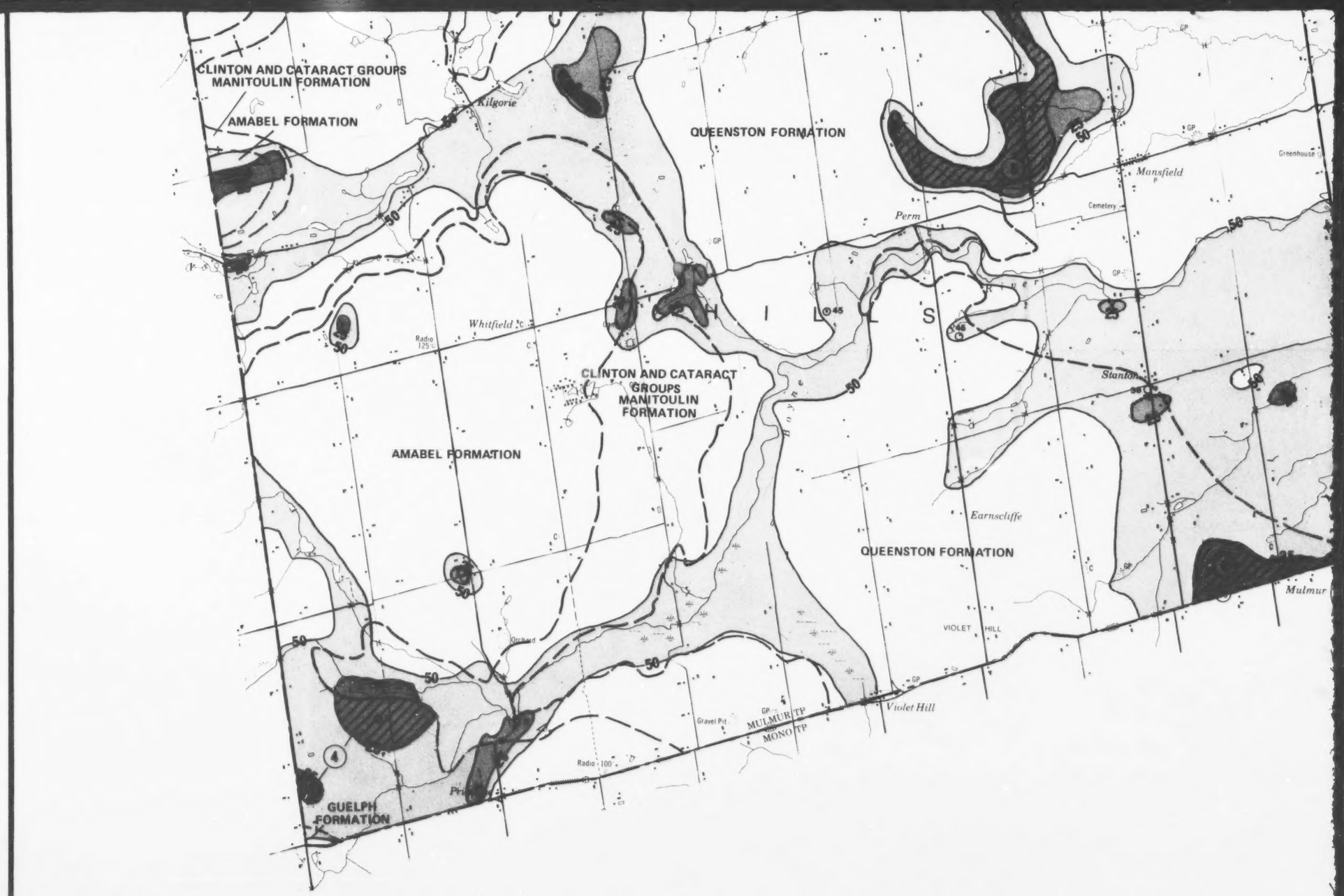
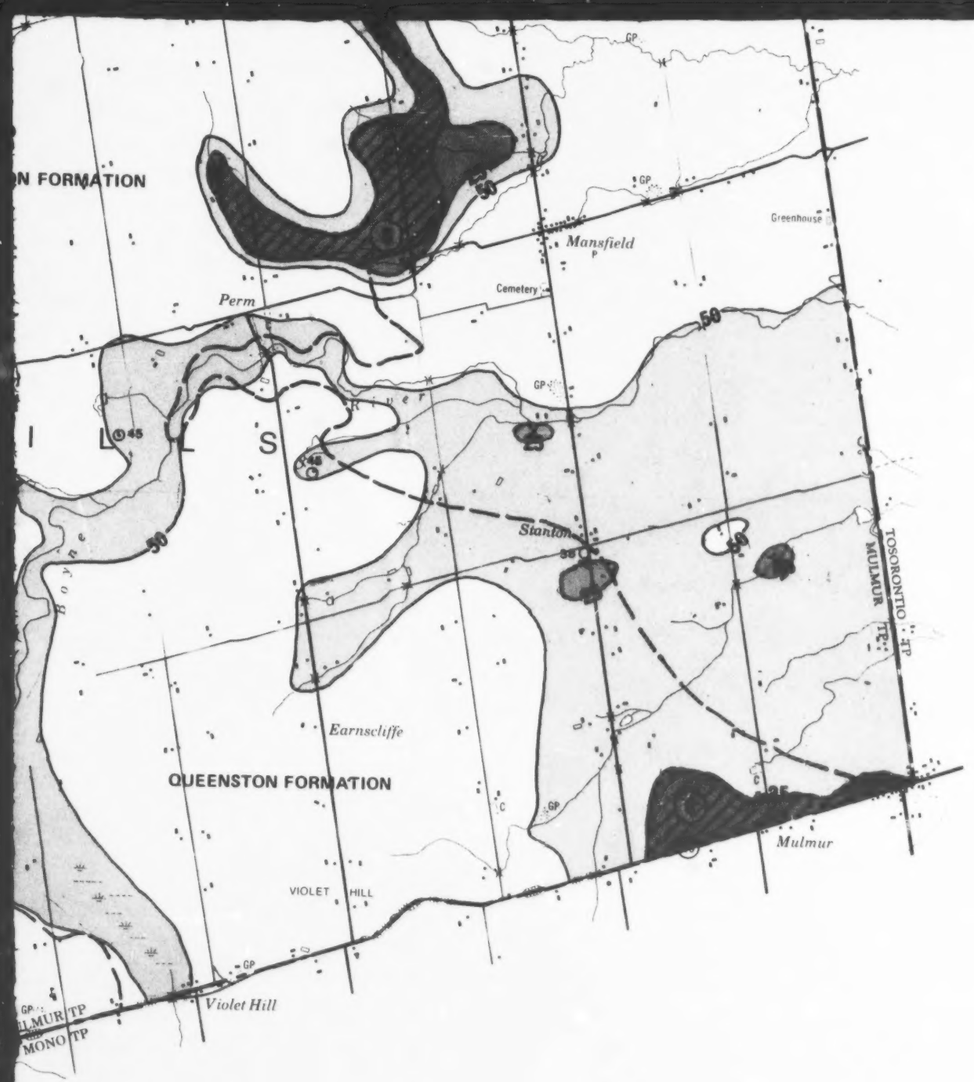

CLINTON AND CATARACT GROUPS
MANITOULIN FORMATION
AMABEL FORMATION
Kilgorie
QUEENSTON FORMATION
Mansfield
Greenhouse
Cemetery
Perm
H I L L S
Whitfield
Radio 125
CLINTON AND CATARACT GROUPS
MANITOULIN FORMATION
AMABEL FORMATION
Stanton
Earnscliffe
QUEENSTON FORMATION
Mulmur
VIOLET HILL
Orchard
Gravel Pit
MULMUR TP
MONO TP
Violet Hill
Radio 100
GUELPH FORMATION
50
45
GP



MULMUR

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